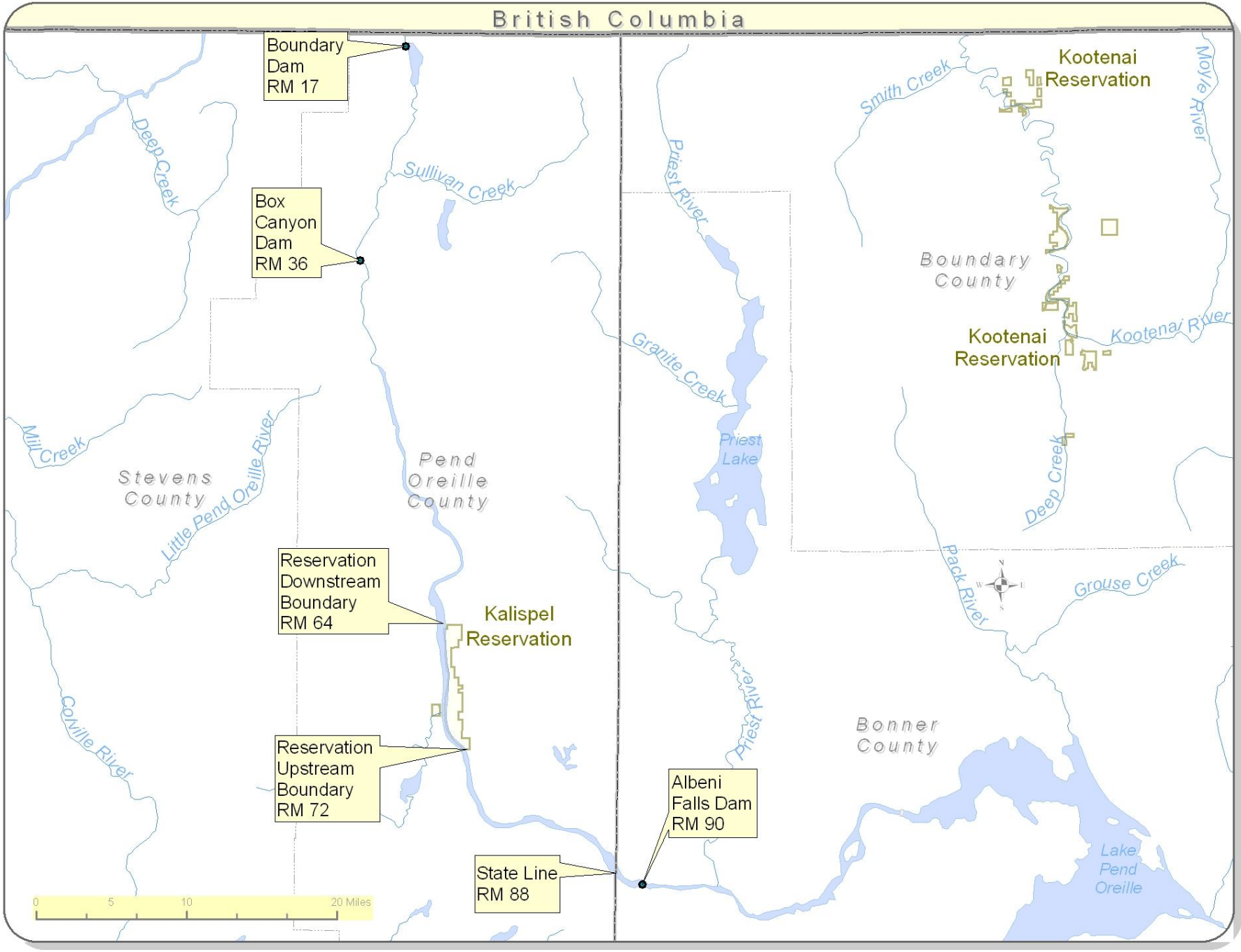
Pend Oreille River Temperature TMDL

Introduction

- History of the TMDL
- Basic Introduction to Daily Comparison and Cumulative Frequency Analysis (CFA)
- Why the TMDL should be approved
- Specific Issues
  - Exceedences Using the Different Methods
  - Daily Maximum Criteria
  - State Line Heat Loading
  - Tribal WQS and Sovereignty
  - Reasons Ecology chose CFA
  - Data Pooling Period
  - Use of CFA with Interdependent Data


British Columbia
Boundary Dam RM 17
Box Canyon Dam RM 36
Reservation Downstream Boundary RM 64
Kalispel Reservation
Reservation Upstream Boundary RM 72
State Line RM 88
Albeni Falls Dam RM 90
Kootenai Reservation
Kootenai Reservation
Deep Creek
Sullivan Creek
Mill Creek
Little Pend Oreille River
Colville River
Stevens County
Pend Oreille County
Priest River
Granite Creek
Priest Lake
Priest River
Smith Creek
Moyie River
Boundary County
Kootenai River
Deep Creek
Pack River
Grouse Creek
Bonner County
Lake Pend Oreille
0 5 10 20 Miles

TMDL History

- **2004 - 2007** EPA, Kalispel Tribe, States of Washington and Idaho collaborate on TMDL
- **May 2004 –** MOA between States, Tribe and EPA signed
- **July 2007** Draft Interjurisdictional TMDL shared with stakeholders
- **July 2007 – December 2009**
  - States address stakeholder comments on TMDL
  - EPA - Ecology discourse on WQS interpretation
  - Washington moves forward with TMDL using CFA
- **January 2009** - **August 2010** - Two staff meetings between EPA & Kalispel Tribe
- **Fall 2010** – Draft Washington TMDL out for public comment
- **January 2011** Third staff meeting between EPA and Kalispel Tribe

TMDL History

- **Spring 2011** EPA letter to Kalispel Tribe offering consultation; Tribe accepts
- **April 2011** Ecology submits TMDL to EPA; Dam operators request dispute resolution & file lawsuits
- **Summer 2011** Consultation between RA & Tribal Chairman in Spokane, followed by RA letter
- **August 2011** Dispute Resolution Process completed;
- **November 2011** Ecology submits final TMDL; Fourth Meeting between EPA & Tribal staff
- **February 2012** Phone conversation and follow up letter from Office of Water Director, Mike Bussell to Deane Osterman at Kalispel Tribe Natural Resources Department
- **Spring Summer 2012** – 2 FOIAs and FOIA appeal by Tribe
- **July 2012** – HQ meeting with Tribe

2004 MOA

- The MOA was only partially completed (no interjurisdictional TMDL) due to loss of funding in Idaho and this dispute between Ecology and the Tribe
- The MOA was not a binding agreement, and all parties understood this
- The collaboration that occurred under the MOA was invaluable to all parties – building models that are based on consistent assumptions and data, forming a strong technical basis for the TMDL

EPA Support for Tribe

- Provided the Tribe with $105,000 in grant and contract funding for work related to the TMDL
- Negotiated for over a year with Ecology to reverse a Pend Oreille River standards interpretation that was opposed by the Tribe
- Successfully intervened on proposed changes to TMDL from dispute resolution process in response to Tribe's comments
- Multiple meetings with Tribe attempting to resolve their issues with TMDL

Tribal Interest

- Tribe is satisfied with allocations at Boundary and Box Canyon Dams
- Primary Issue: Albeni Falls Dam and determination of heat loading at state line
- Interest in using the TMDL to leverage discussions with the Corps re: Albeni Falls Dam

Technical primer:
Daily Comparison and CFA Methods

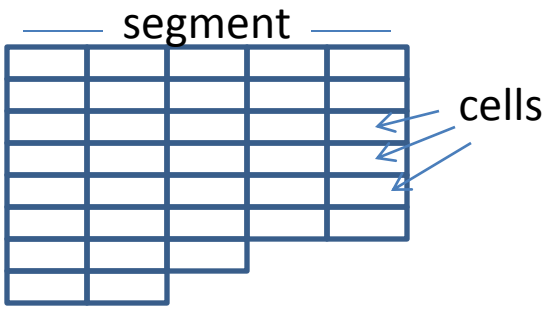
Washington Temperature Criteria

- Temperature shall not exceed a 1-day maximum (1-DMax) of 20°C due to human activities.

- When natural conditions exceed a 1-DMax of 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C

The model

- The TMDL divides the river into segments along its length
  - Each segment is a collection of model cells (vertical and horizontal)
- Data generated for each segment on half hour intervals for 2004 and 2005
  - Max daily value from all cells in segment is selected as segment value, consistent with max daily criteria
- Two model runs
  - a Natural Conditions simulation without the dams
  - an Existing Conditions simulation
- Each simulation has data for every segment and every half hour over the two years modeled

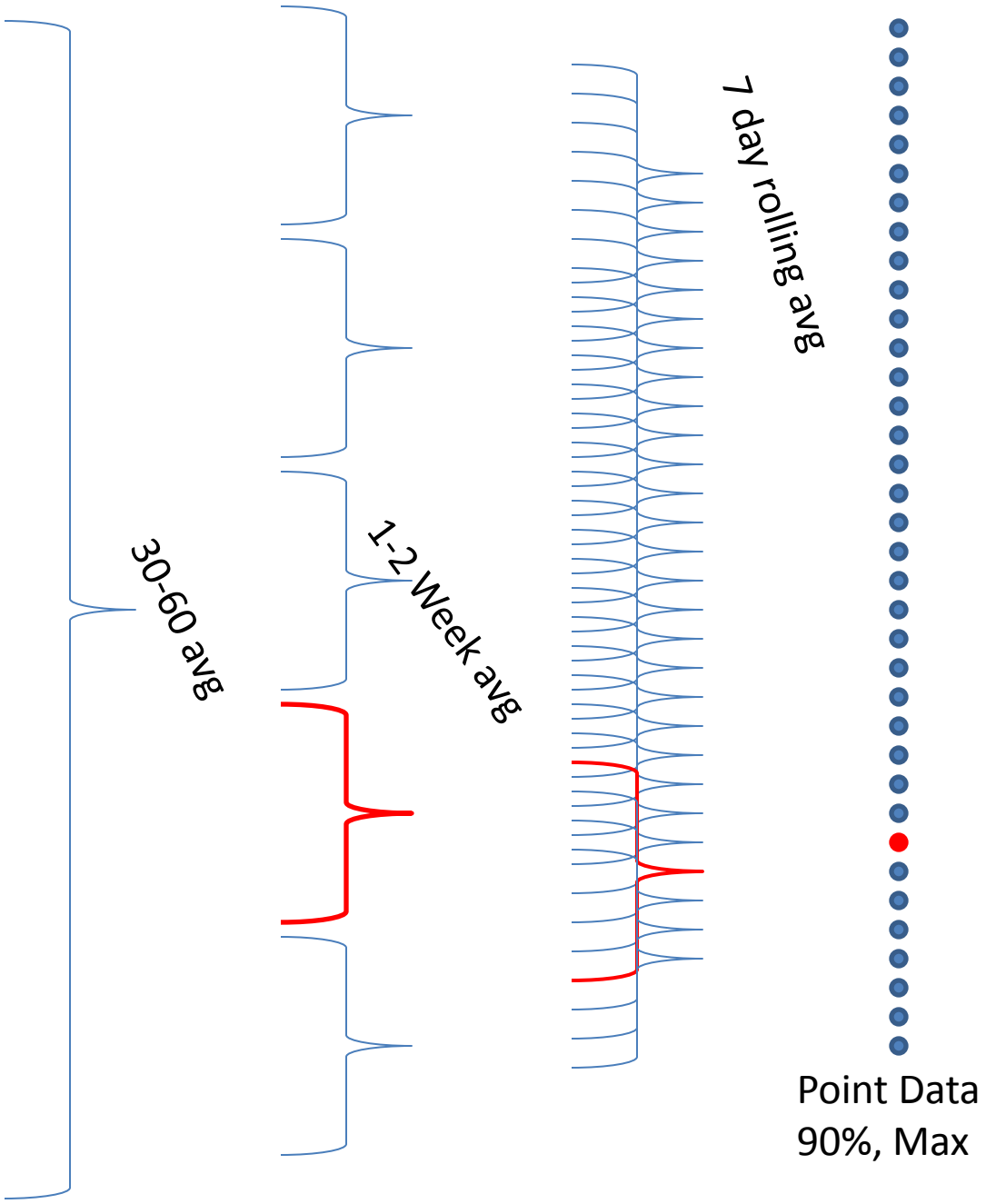


Daily Comparison Method

- Compares the maximum daily temperatures from the Existing Conditions simulation to data from the same time and location in the Natural Conditions simulation
  - the difference, minus the 0.3 human use allowance, is the magnitude of impairment
- Daily differences can then be aggregated, statistics calculated, etc.
- Tribe is advocating daily comparison with no aggregation and no statistics – i.e., maximum values, “excursions”

Date	Natural	Existing	Diff
06/30/05	19.41	18.58	-0.83
07/01/05	19.98	19.07	-0.91
07/02/05	20.43	19.27	-1.17
07/03/05	20.51	19.52	-0.99
07/04/05	20.19	19.90	-0.29
07/05/05	20.16	20.05	-0.10
07/06/05	20.43	19.75	-0.69
07/07/05	20.76	19.87	-0.89
07/08/05	21.11	20.03	-1.09
07/09/05	20.74	20.13	-0.60
07/10/0			.68
07/11/0			.20
07/12/05	20.39	20.55	0.16
07/13/05	20.69	20.58	-0.11
07/14/05	21.19	20.52	-0.67
07/15/05	21.39	20.53	-0.86
07/16/05	21.31	20.57	-0.74
07/17/05	22.25	20.88	-1.38
07/18/05	22.90	21.37	-1.52
07/19/05	22.59	21.78	-0.81
07/20/05	22.96	21.80	-1.16
07/21/05	23.52	22.08	-1.45
07/22/05	22.44	21.95	-0.49
07/23/05	23.28	21.83	-1.45
07/24/05	23.71	21.85	-1.86
07/25/05	23.43	21.97	-1.47
07/26/05	23.46	22.26	-1.20
07/27/05	23.64	22.52	-1.12
07/28/05	23.62	22.69	-0.93
07/29/05	23.60	22.72	-0.88

Daily comparison



Disadvantages of Single Value Approach

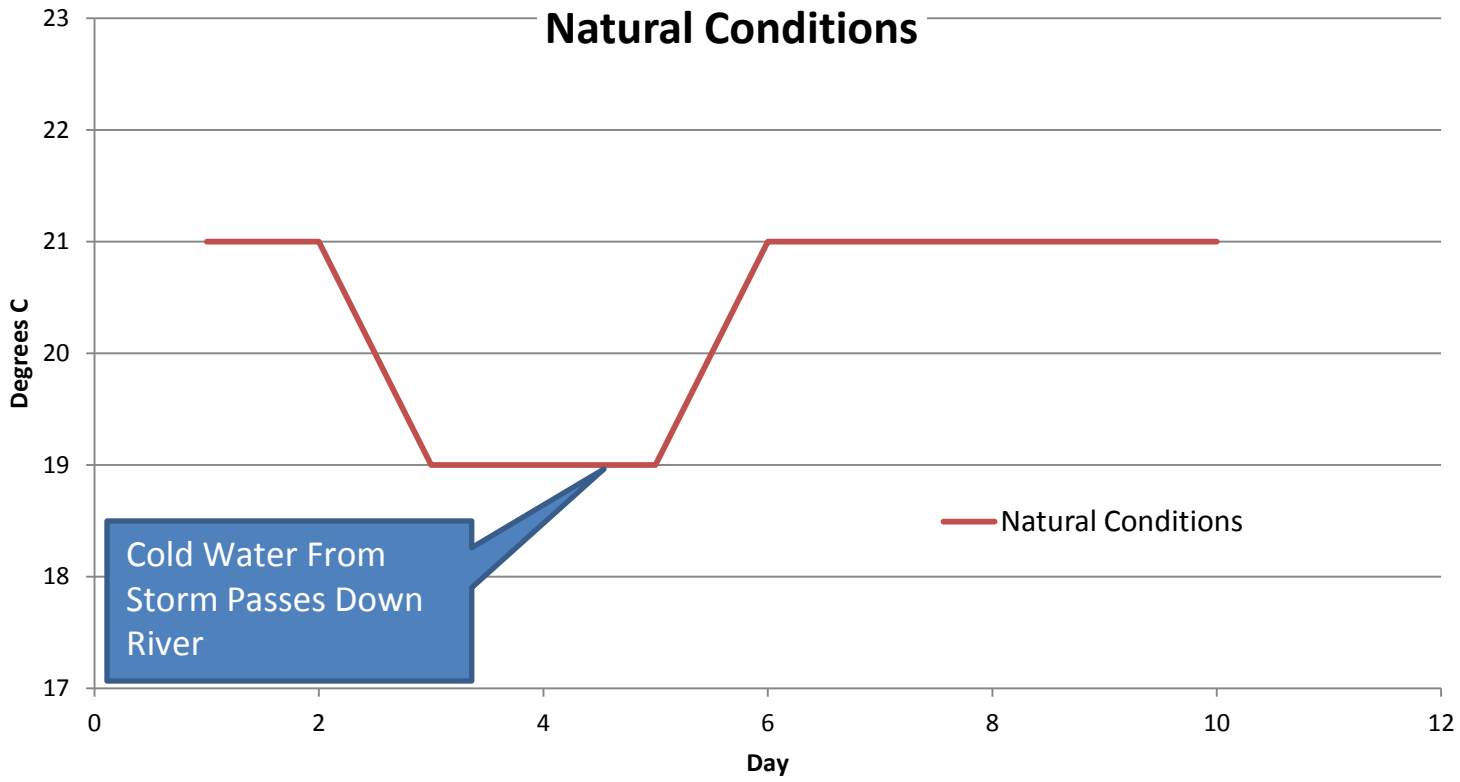
- Susceptible to bias due to short-term time lags
- Relies on model predictions at a single time and cell location.
  - Reasonable concern about uncertainty inherent in complex models
  - Science issue, not just legal/policy
- Focus on single day “violations” rather than loading capacity and allocations
  - TMDLs commonly aggregate data to set allocations (weekly/monthly/seasonal)
- No TMDLs in R10 have used single day max value from 2 dimensional models to set allocations

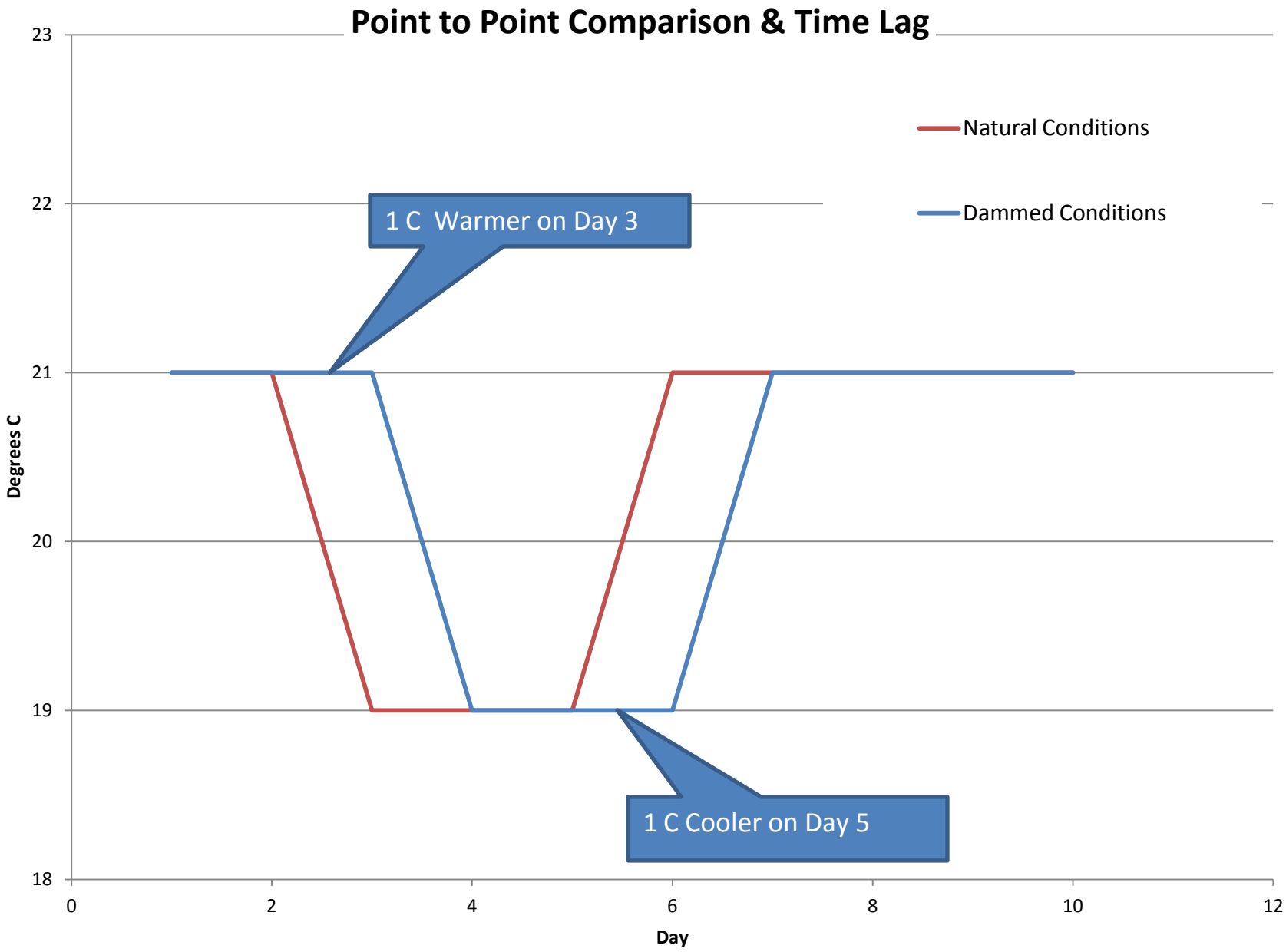
Time Lag

- Model simulates continues response of river to weather conditions
- Dams slow the travel time of water in a river
- Cold weather front causes temperature drop.
- Cold “pulse” in river passes a model segment later due to dams.
- Daily Comparison “snapshot” captures the timing change as an impact.

Time Lag

- Conceptual diagram – fixed location
- Pulse due to storm onsite and cessation




Point to Point Comparison & Time Lag
Natural Conditions
Dammed Conditions
1 C Warmer on Day 3
1 C Cooler on Day 5
Degrees C
Day
23
22
21
20
19
18
0
2
4
6
8
10
12

Lag effect – impact or artifact?

- Distribution of daily max temperatures is the same, but timing is not
- Timing is different by a matter of days, and impact is not persistent
- Is this an impact of concern?
- Or an artifact of the daily comparison analysis caused more by natural (storm) conditions than human actions (dam construction)?
- CFA is used to filter out time lag effects and focus on more definitive human impacts to temperature

Cumulative Frequency Analysis

- CFA is a statistical analysis of two data sets
- Data distributions are compared at each rank percentile value (frequency of occurrence in the data pool)
- One cannot do a cumulative frequency analysis without first aggregating (pooling) the data

Lowest temp

Rank	Natural	Existing	Diff
1	18.58	19.41	0.83
2	19.07	19.98	0.91
3	19.27	20.16	0.89
4	19.52	20.19	0.67
5	19.75	20.37	0.62
6	19.87	20.39	0.52
7	19.87	20.43	0.56
8	19.9	20.43	0.53
9	20.03	20.51	0.48
10	20.05	20.55	0.5
11			
12			
13			
14	20.53	21.11	0.58
15	20.55	21.19	0.64
16	20.57	21.31	0.74
17	20.58	21.39	0.81
18	20.88	22.25	1.37
19	21.37	22.44	1.07
20	21.78	22.59	0.81
21	21.8	22.9	1.1
22	21.83	22.96	1.13
23	21.85	23.28	1.43
24	21.95	23.43	1.48
25	21.97	23.46	1.49
26	22.08	23.52	1.44
27	22.26	23.6	1.34
28	22.52	23.62	1.1
29	22.69	23.64	0.95
30	22.71	23.71	1
31	22.72	23.83	1.11
32	22.74	24.09	1.35
33	22.82	24.2	1.38

Highest temp

CFA ANALYSIS

Challenge in applying CFA:
- Selection of pooling period

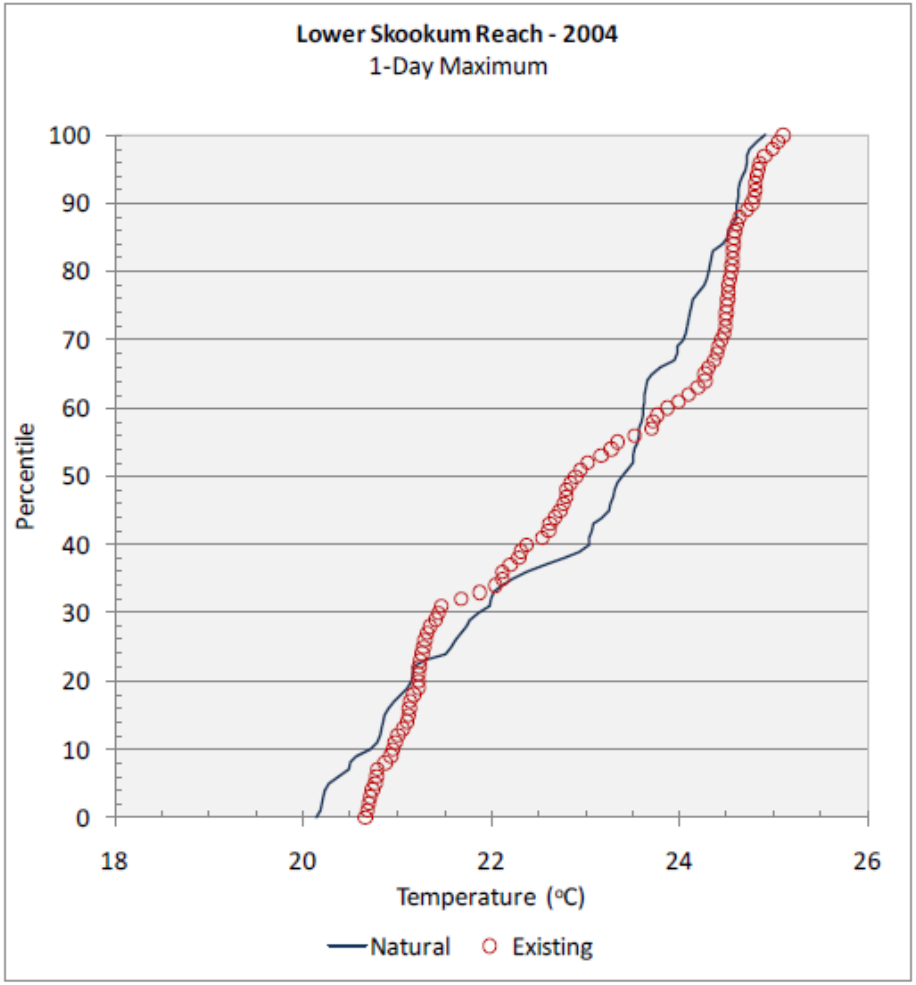
WA approach: Drawn directly from standard language

“When natural conditions exceed criterion…”

TMDL uses maximum difference for all ranked pairs

CFA in TMDL

- The daily maximum data points in the existing conditions simulation that exceed each criteria were pooled (about 62 days)
  - Consistent with 2 part language in standard
- The corresponding data points (same location, same time) in the natural conditions simulation were also pooled
- These pools of data were then plotted by cumulative frequency of occurrence in the data set



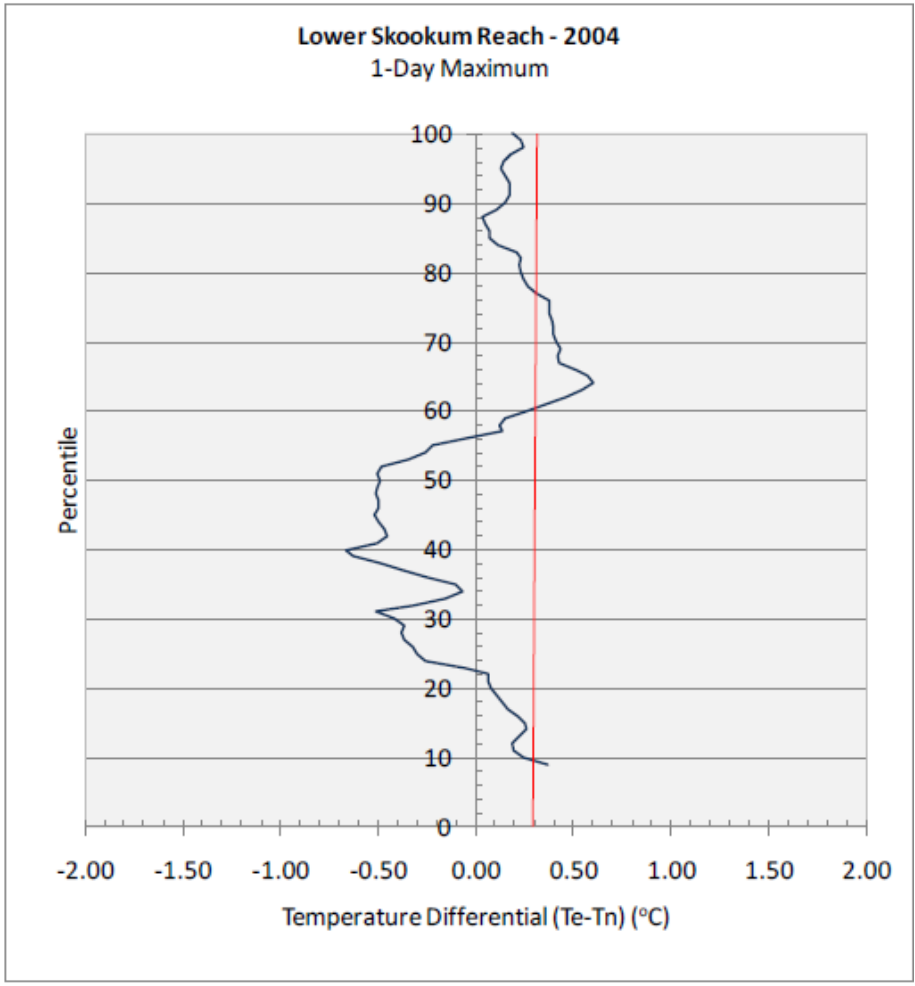


Figure 22. Segment 115 cumulative frequency distribution of daily maximum temperatures along with the associated temperature differential. *Analysis includes the natural and existing conditions observed at lower Skookum reach (segment 115) in 2004.*

Why the TMDL should be approved

- State has discretion on model data analysis method
  - Standards do not describe or address analysis issues and methods
  - Discretion in scientific work is important to maintain
- Reasonable to aggregate model predictions
  - Common response to model uncertainty/error
  - Single model-data-point excursions not the same as allocations
- Time lags are real
  - CFA is reasonable response to concern
  - CFA as used in the TMDL is technically acceptable
- Idaho/Washington state line temperature conditions meet WQS
- Risks associated with disapproval
  - PdO river and TMDL
  - programmatic impact
  - NPDES Permit renewal for Ponderay Newsprint

Why the TMDL should be approved

I. State discretion in analytical method selection

- Standards set the target but do not prescribe technical analysis method for TMDLs
- No guidance in standards on applying the standard, including model type/selection, data aggregation, allocation time frame, model uncertainty, margin of safety, or unique effects of dams on temperature
- State is afforded deference in standards interpretation and TMDL allocation method
- Technical work must be transparent and aligned with standard to extent practicable.
  - PdO TMDL meets this test

Washington's Temperature Criteria provides no technical guidance

- Temperature shall not exceed a 1-day maximum (1-DMax) of 20°C due to human activities.
- When natural conditions exceed a 1-DMax of 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C
- WA chose pooling period consistent with underlined clause above
- Period is July-August (62 days, not 93 days as tribe asserts)

Kalispel Standard – similar level of detail as WA standard

- Temperature shall not exceed 18°C as a moving 7-day average of the daily maximum temperatures with no single daily maximum temperature greater than 20.5°C.

- When natural background conditions prevent the attainment of the numeric temperature criteria, human-caused conditions and activities considered cumulatively can increase temperature levels by only an additional 0.3°C.

- WA pooling period consistent with underlined clause above.

Why the TMDL should be approved

II. Reasonable to aggregate model predictions

- Statistical analysis is common and useful
  - Requires pooling of data
  - Helps avoid regulating based on extreme or highly unusual conditions
- Common response to model uncertainty/error
- Necessary to develop reasonable TMDL

Use of CFA in TMDLs
An Incomplete List

- Willamette River Temperature TMDL, OR, 2006
- Florida Mercury TMDL, 2012
- Commonly used in bacteria TMDLs in many states including, CT, HI, ND, DE, NC, NJ, OR, AZ, TN, TX
- Stockton Deep Water Shipping Canal Dissolved Oxygen TMDL, CA, 2005
- Muddy Creek and the Yadkin River Turbidity TMDL, NC, 2011
- Upper Clinch Watershed pH TMDL, TN, 2009
- Potomac Estuary PCB TMDL, DC, 2007
- Lake Elsinore and Canyon Lake Nutrient TMDL, CA, 2005
- Buckhannon River pH and metals TMDL, WV, 2010
- Indian Creek, Southampton Creek Paxton Creek and Goose Creek and Sawmill Run Watersheds total phosphorus and sediment TMDLs, PA (Issued by EPA) 2008
- Ridenour Lake Metals TMDL, WV,

Excursions are one thing, allocations are another

- TMDL allocations are never set for individual calendar dates
  - e.g., bi-weekly, monthly, seasonal allocations
  - aggregation of impact estimates is the norm

Allocation time frames in recently approved TMDLs with dam allocations:

Willamette River – monthly
Spokane River – bi-weekly
Klamath River - monthly

Why the TMDL should be approved

III. Time lags are real & analysis indicates Daily Comparison shows these as exceedences

Use of CFA

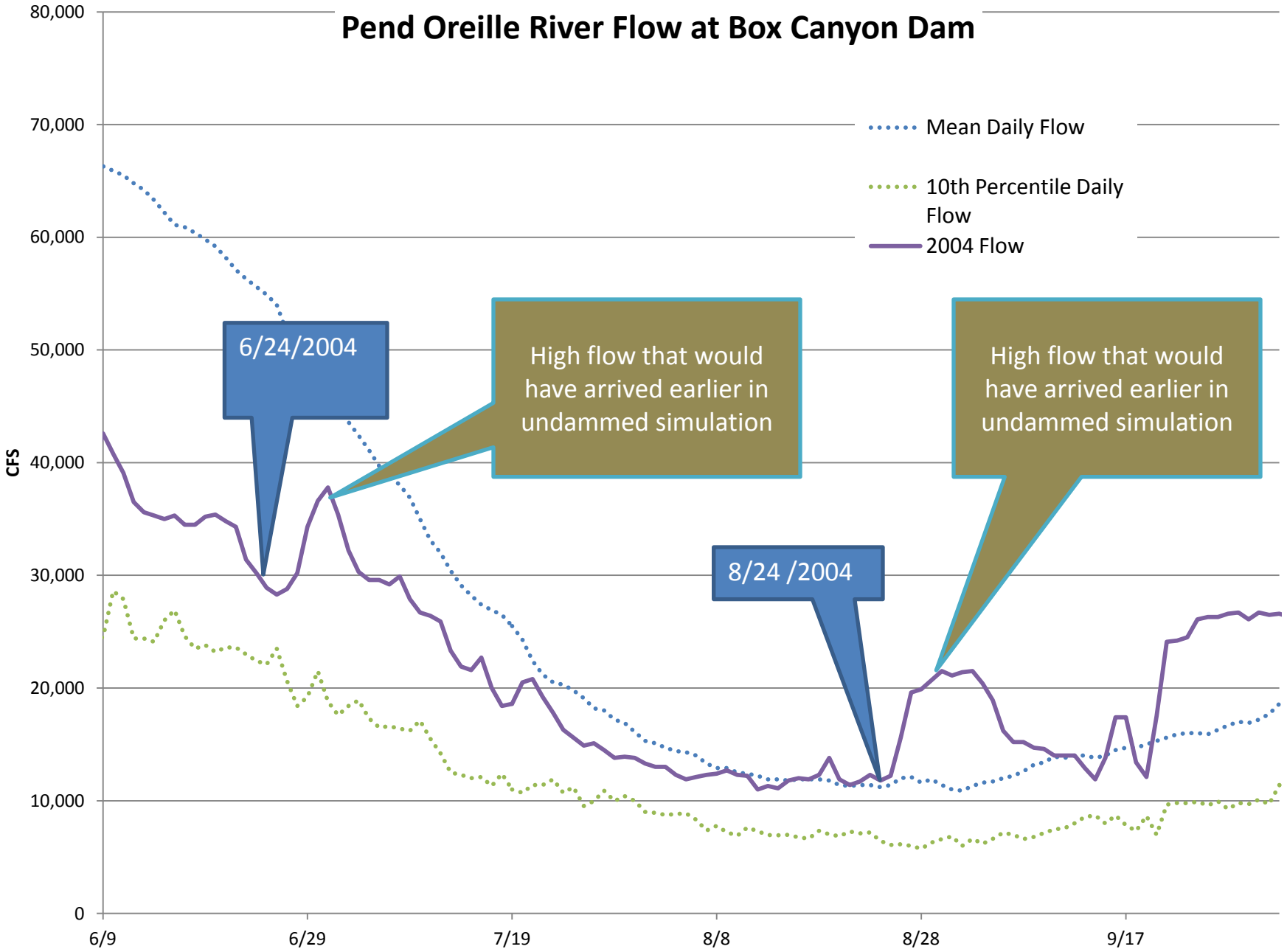
- We looked at exceedences of the daily max criteria that also exceeded TMDL allocations in tribal waters.
- This analysis showed convincing evidence of time lag effects in the upstream reaches (near the reservation) as well.
- Ecology has indicated that the time lag issues are more clear/problematic at the downstream end of the study area.
- Important to have technical method consistency across entire study area.

R10 Analysis of Time Lags

- We evaluated whether the Daily Comparison exceedences resulted from time lag using:
  - Flow Data
  - Weather Data
  - Plots of the model data

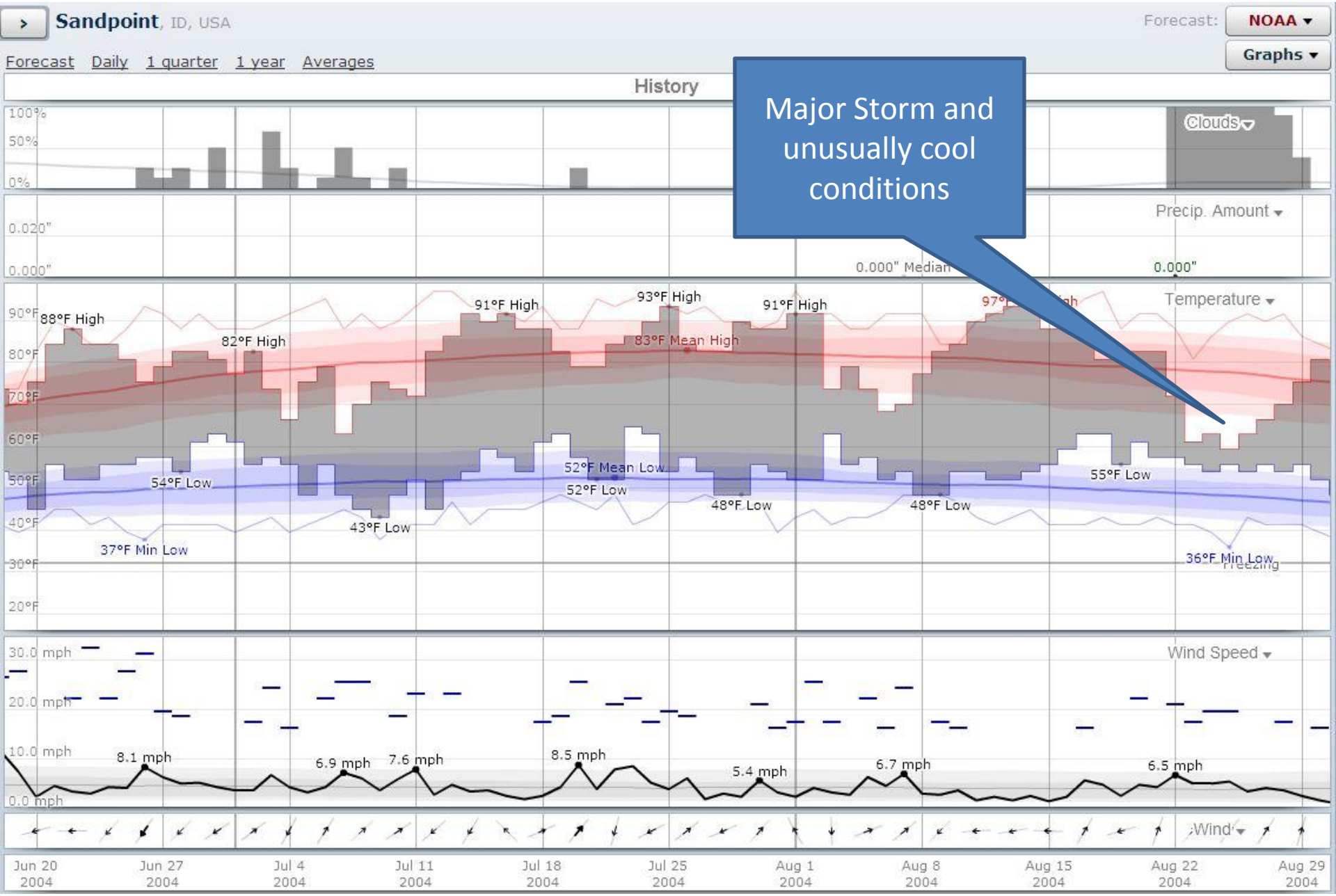
Flow Data

- The Daily Comparison model analysis exceedences above the Load Allocation & TMDL reductions occur
  - June 24, 2004
  - June 30 – July 1, 2004
  - August 24 – 29, 2004
  - Note that there were no exceedences in 2005. The TMDL set allocations based on data from 2004 as part of MOS – warmer, low water year.
- The first and last dates immediately precede a large increase in flow in the river that would have cooled stream temperatures and reached the same location earlier than in the undammed simulation


Pend Oreille River Flow at Box Canyon Dam
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
CFS
6/9
6/29
7/19
8/8
8/28
9/17
Mean Daily Flow
10th Percentile Daily Flow
2004 Flow
6/24/2004
High flow that would have arrived earlier in undammed simulation
8/24 /2004
High flow that would have arrived earlier in undammed simulation

Weather Data

- Evidence from all climate stations used in model shows 90% cloud cover, high precipitation and unusually cool conditions between August 22 and 29, 2004, when half of the exceedences occurred
- Deer Park, Newport, Felts Field, and Tacoma Creek stations show storm conditions on June 30, 2004
- Local stations show some rain fall on June 24, 2004


Sandpoint, ID, USA
Forecast: NOAA
Graphs
Forecast Daily 1 quarter 1 year Averages
History
Major Storm and unusually cool conditions
Clouds
100%
50%
0%
Precip. Amount
0.020"
0.000"
0.000" Median
0.000"
Temperature
90°F
80°F
70°F
60°F
50°F
40°F
30°F
20°F
88°F High
82°F High
91°F High
93°F High
91°F High
83°F Mean High
54°F Low
37°F Min Low
43°F Low
52°F Mean Low
52°F Low
48°F Low
48°F Low
55°F Low
36°F Min Low
Freezing
Wind Speed
30.0 mph
20.0 mph
10.0 mph
0.0 mph
8.1 mph
6.9 mph
7.6 mph
8.5 mph
5.4 mph
6.7 mph
6.5 mph
Wind
Jun 20 2004
Jun 27 2004
Jul 4 2004
Jul 11 2004
Jul 18 2004
Jul 25 2004
Aug 1 2004
Aug 8 2004
Aug 15 2004
Aug 22 2004
Aug 29 2004

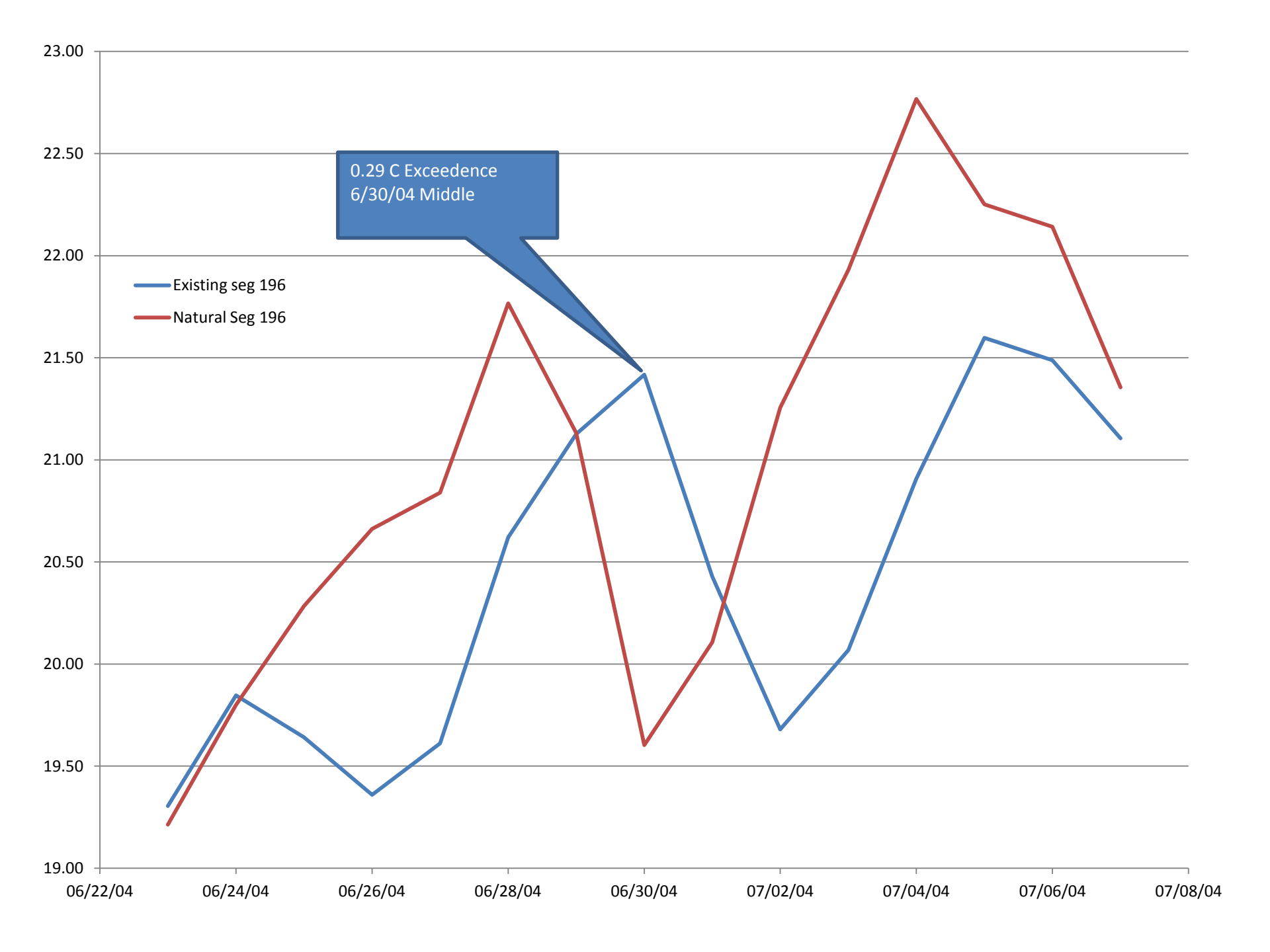
Graphs of Data Show Time Lag

Analyzed instances when Box Canyon LA is smaller than Daily Comparison value

--- Time lag explains 6 out of 8 instances

Also analyzed instances when natural was below criterion and existing was above

--- Time lag explains 11 out of 13 instances


23.00
22.50
22.00
21.50
21.00
20.50
20.00
19.50
19.00
06/22/04
06/24/04
06/26/04
06/28/04
06/30/04
07/02/04
07/04/04
07/06/04
07/08/04
0.29 C Exceedence
6/30/04 Middle
Existing seg 196
Natural Seg 196

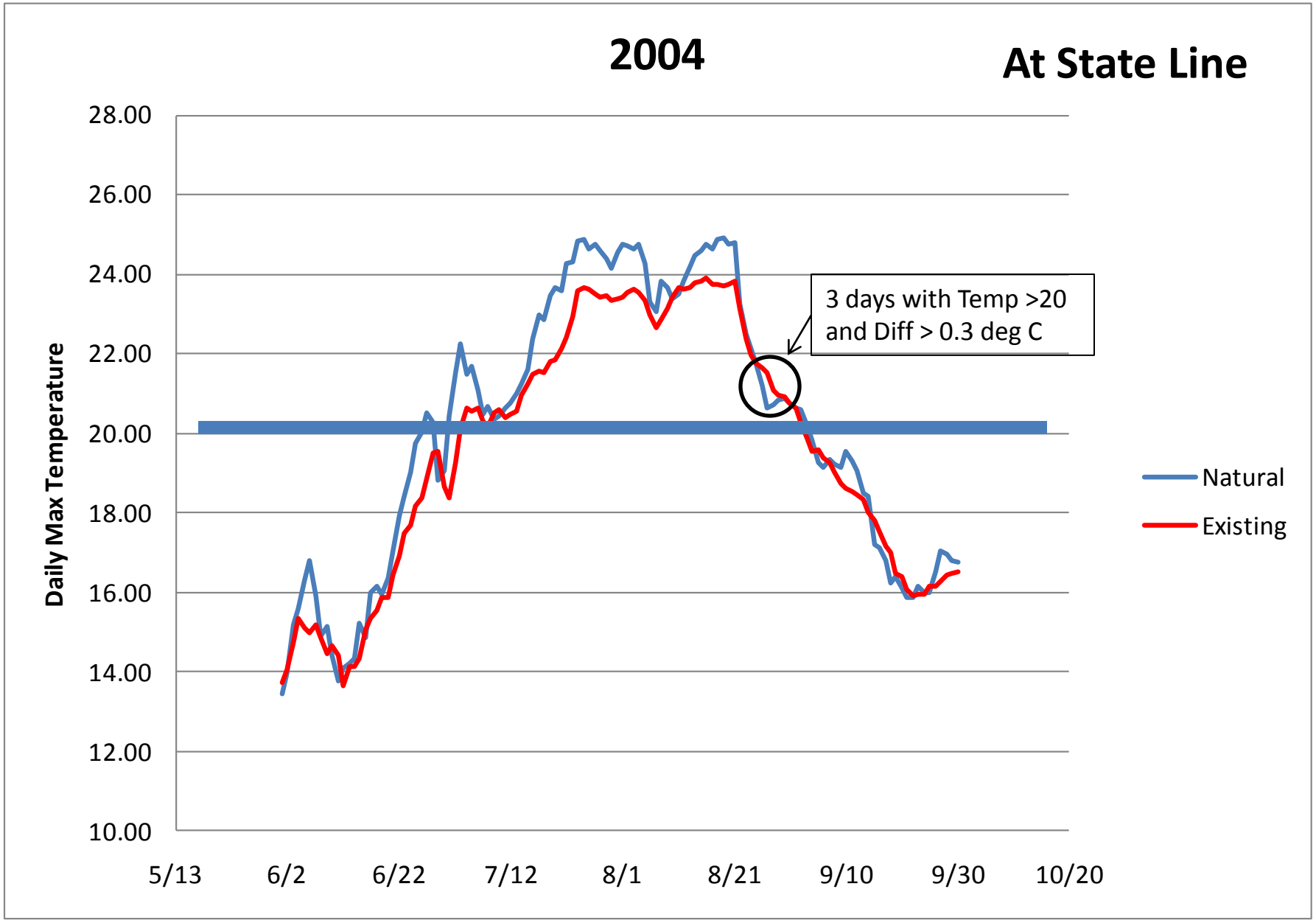
Summary of Evidence that Daily Maximum Criteria Exceedences Are Caused by Natural Effects					
Date	**Segment**	**Degrees C Over Load Allocation/ Reduction**	**Plots Show Time Lag**	**Flow Data**	**Local Weather Data**
6/24/04	357	0.20		X	Fair
6/24/04	332	0.17		X	Fair
6/30/04	196	0.29	X		Strong
7/1/04	347	1.11	X		Strong
8/24/04	358	1.15	X	X	Strong
8/24/04	316 – 319	0.92	X	X	Strong
8/25/04	358	0.48	X	X	Strong
8/25/04	347	0.08	X	X	Strong
6/30/04	172	0.45	X		Strong
8/24/04	172	0.01	X	X	Strong
8/27/04	115	0.54		X	Strong
8/28/04	115	0.43		X	Strong
8/29/04	115	0.45		X	Strong

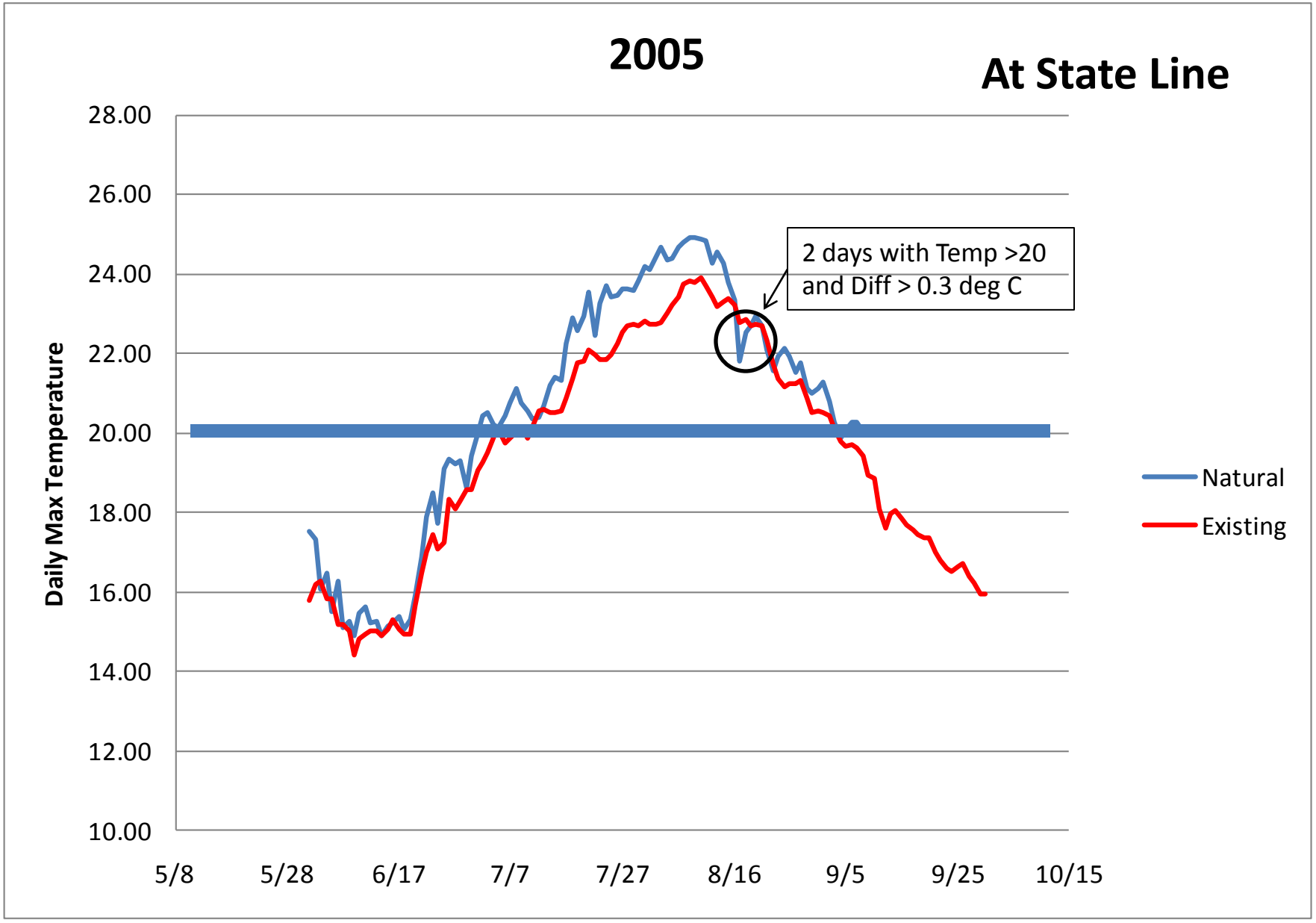
CFA in the TMDL

- **Our review of the TMDL indicates that Ecology had a sound scientific rationale for adopting CFA**
- **TMDL allocations are much more stringent than they might have been had Ecology used a more common analysis method such as volume weighted averaging or used a one dimensional model with Daily Comparison**
- **Concerns brought up about using CFA with CEQUAL-W2 (interrelated) data are not valid for analysis in TMDL**
- **There is no evidence of bias or that CFA was adopted for non-scientific reasons**
  - **The dam operators were dissatisfied enough with the allocations that they both requested dispute resolution and filed in court to sue Ecology over the TMDL**

Why the TMDL should be approved

IV. Stateline is not impaired


2004
At State Line
Daily Max Temperature
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
5/13
6/2
6/22
7/12
8/1
8/21
9/10
9/30
10/20
3 days with Temp >20
and Diff > 0.3 deg C
Natural
Existing


2005
At State Line
Daily Max Temperature
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
5/8
5/28
6/17
7/7
7/27
8/16
9/5
9/25
10/15
2 days with Temp >20
and Diff > 0.3 deg C
Natural
Existing

Albeni Falls Dam

- Kalispel Tribe makes two assertions

(1) State line is impaired based on the “correct” (Daily Comparison) analytical method

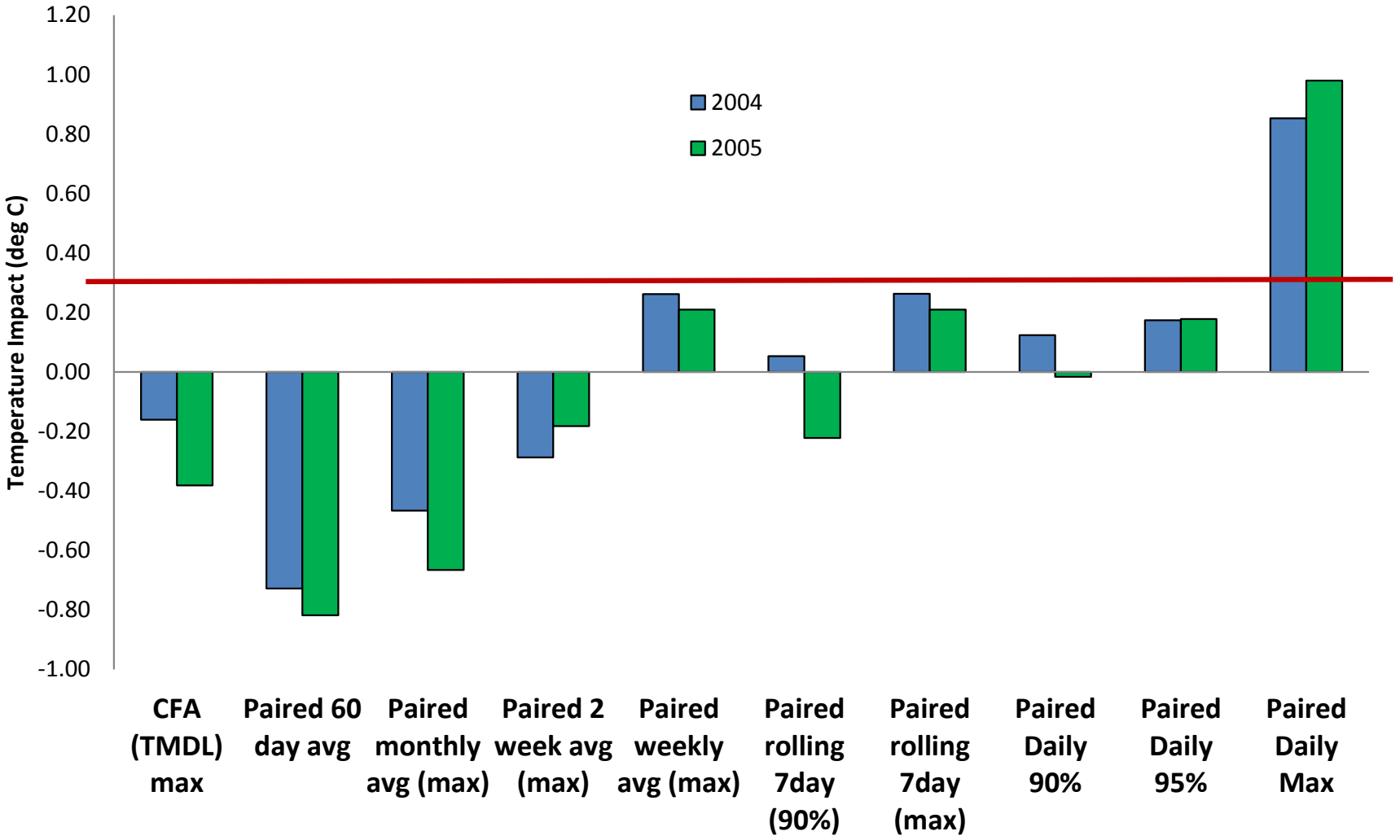
(2) On days when tribal standards are exceeded (downstream of border in tribal waters), Albeni is contributing heat to the river.

- Therefore, Albeni should be assigned a TMDL allocation

Issue 1: Region 10 Analysis of State Line

- Notes
  - River at border is WA state waters
    - This changes geometry, depth, travel time, flow and temperature
  - Multiple slicing/dicing of the model output
    - Seasonal CFA and multiple other analysis methods including Daily Comparison
  - Focused on daily max state standard (20 deg C)
    - July/August is period with temps > 20 deg C
    - Model output is max from water column
      - typically surface temperatures
      - we have not looked at potential volume averaging effects

2004 and 2005 Model Output Analyses
State Line, July/August



State of Washington Impairment Call

- State discretion
- In PdO case, all methods, including Daily Comparison 90th percentile, show impacts less than the 0.3 deg C limit
- One exception: Daily Comparison maximum value
- Weak basis to overrule state decision

Issue 2: Albeni Dam heat contribution

- On almost all days using Daily Comparison, Albeni sends colder-than-natural water across the border
  - Box Canyon PUD is aware of this
- Box Canyon dam forebay temps are generally warmer-than-natural
- TMDL allocation is difference at Box forebay caused by presence of both dams.
  - TMDL allocated temp difference from both dams to Box Canyon
- Box Canyon did not object to LA assignment

Why the TMDL should be approved
V. Potential Consequences of Threatened Disapproval

What happens to the TMDL

- WA does not withdraw TMDL
  - EPA disapproval and modification…in what fashion?

- WA withdraws TMDL and does not replace
  - Years of work lost; no TMDL; frustration on all sides

- WA replaces with a TMDL applying tribe's daily max method AND volume-averaging (next slide).
  - This would be a less stringent, likely approvable TMDL.

- WA follows tribe preferences, sets single-date max value as July-August allocation for Albeni, and is challenged by dam operators

Why the TMDL should be approved

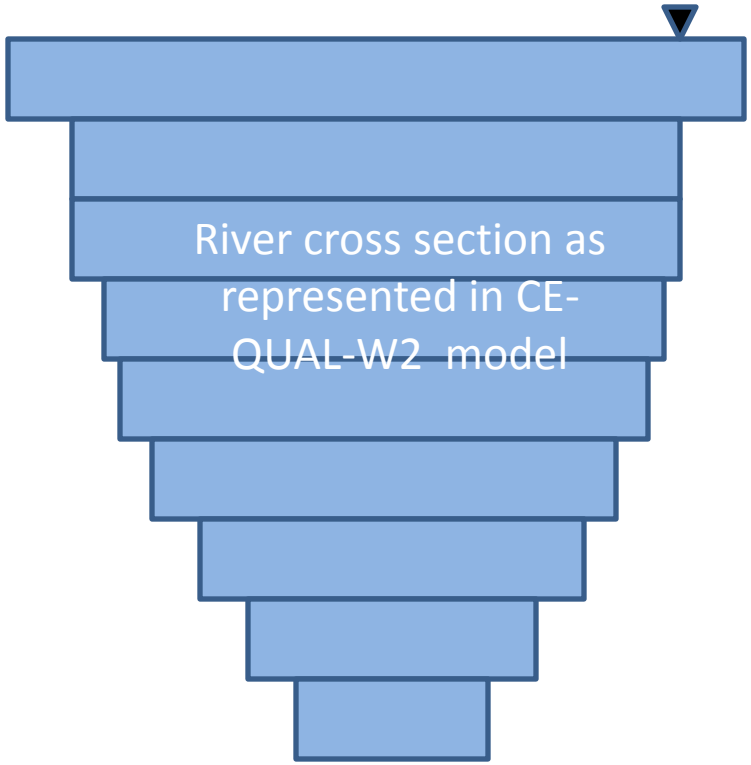
V. Potential Negative Consequences of Disapproval (continued)

- Ponderay Newsprint NPDES permit held up waiting for TMDL
- EPA rejection of data aggregation calls many TMDLs into question and likely puts pressure on WQS program.
  - Changes to interpretation, criteria expression, etc.
  - New avenue for litigation on other TMDLs

Spatial Aggregation: Volume Averaging

Sum of (cell temp x cell volume)/(total volume) = volume-weighted average temperature

24.0	x
23.8	x
23.5	x
23.1	x
22.9	x
22.5	x
22.1	x
21.7	x
21.5	x



- Surface cell has greater volume than bottom, represents more habitat
- Volume-averaging used to get a single value that best represents water column as a whole
- Changes magnitude of estimated impairment

Why Use CFA and Reject Volume Weighted Averaging?

- **Ecology adopted CFA (time-aggregation) but not Volume Weighted Averaging(spatial aggregation).**
- **CFA was chosen by Ecology to reduce model uncertainty and time lag effects without masking the dams' impacts**
- **Volume weighted averaging would have reduced allocations**
- **It is good science to examine and select model-data processing methods that account for model uncertainty, water quality standards metrics, allocation challenges, and other technical and policy considerations.**

Conservative Decisions Made by Ecology

- **Use of maximum cell temperature**
- **No volume weighted averaging**
- **Use of maximum difference from the CFA rather than averaging the differences**
- **For allocations, use of data from the warmer/ lower water year (2004) rather than typical year (2005)**
- **Stringent interpretation of winter season WQS for Pend Oreille River**

Conclusion

- Time lags are real concern
- Standards language does not offer any technical guidance
- Model data aggregation and monthly and seasonal allocations are common in TMDLs
- CFA is reasonable approach
- Stateline is unimpaired
- Unintended consequences are negative for river and program

Next Steps

- Region 10 believes approval is appropriate
- If that is not the agreed-upon direction, R10 and HQ develop detailed comments and direction on this TMDL
- Devise next steps in communication to Tribe and Ecology and possibly other stakeholders
- Anticipate litigation either way

Time permitting…we can include more detail from Helen's excursion analysis below

Difference in Results - CFA vs Daily Comparison

- Review of model data from 8 of the 12 modeled reaches (Box Canyon Forebay – Stateline) in WA for 2004 & 2005 using Daily Comparison
  - 20 C is exceeded 1,147 times
  - In 39 of these instances the daily maximum criteria applied (3.4%)
  - Only 8 of these exceedences were greater than the load allocation for Box Canyon Dam
    - Average exceedence of the load allocation was 0.24 C
    - maximum exceedence was 1.15 C

TMDL Analysis Consistent with WQS

- The TMDL treats all exceedences as though the natural conditions criteria apply.
- The 0.3 C human use allowance is used for all exceedences, but is not allowed where the daily maximum criteria apply.
- Our daily comparison analysis found 13 days where the daily maximum criteria applied and the magnitude of exceedence was greater than the TMDL allocations
- There was strong evidence of time lag effects due to natural conditions on these days